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Component Combination and Frame-Embedding in Chinese Character Grammars

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Component Combination and Frame-Embedding in Chinese Character Grammars

Kirk Rankin and James L. Tan

Systems Development Division
Center for Computer Sciences and Technology
National Bureau of Standards
Washington, D.C. 20234

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Component Combination and Frame-embedding in Chinese Character Grammars

Kirk Rankin and James L. Tan

Chinese characters can be almost completely described from the point of view that each character is composed of a number of components and that each component is composed of a number of strokes. This note offers a grammatical treatment of component combination. It is concerned with the three most productive processes of component arrangement. This grammar differs from previous grammars in that the constraints on recursion have been minimized and great lexical economy has been achieved.

Key words: Chinese characters; grammar; generative grammar; component combination; linguistics; frame-embedding; blocking.

1. Introduction

This note is one of a series which is generally concerned with the linguistic study of the formation of Chinese characters.[1] It offers a particular treatment of one aspect of the general study. In this preface we wish to establish a frame of reference for placing the treatment offered here within the general study. To that end we will initiate a discussion of the formation of Chinese characters and will successively focus our attention on less general aspects of it until the treatment in this note is reasonably well characterized.

Concerning the formation of Chinese characters the following comments can be made. It has been observed that the internal structure of Chinese characters bears certain resemblances to the internal structure of natural language sentences.[2] For example, sentences can be viewed as being composed of word sequences and ultimately of words or word-parts, and words and word-parts can be viewed as being sequences of sound units. Analogously, Chinese characters can be almost completely described as being composed of a number of components, components in turn being composed of a number of strokes. Thus 後 , a character, is composed of three components (彳 , 幺 , and 夂). In turn, 彳 is composed of the strokes 丿 , 丿 , and 丨 ; 幺 is composed of the strokes く , ㄥ , and 丶 ; and 夂 is composed of the strokes 丿 , フ , and ㇏ .

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[1] Burkart (1), Rankin (3), Rankin et al.(4), Rankin et al.(5) (see references) are the other publications in the series.

This note is restricted to the area of component combination, the manner in which characters are composed of components. Examples of characters analyzed in terms of components are:

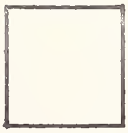
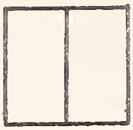
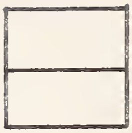
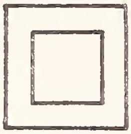
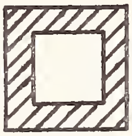
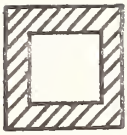
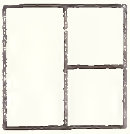
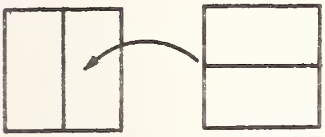
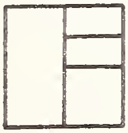
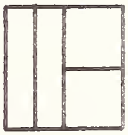
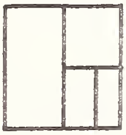
Character	Component(s)
木	木
相	木, 目
亢	亠, 几
困	口, 木
近	辶, 斤
庫	广, 車

---

[2] See Rankin (3), especially Chapter VIII, for a detailed discussion of this point.

Character	Component(s)
可	丁, 口
後	彳, 幺, 夂
清	氵, 龶, 月
路	口, 止, 夂, 口
絍	幺, …, 亻, 壬
高	亠, 口, 冂, 口

The concept of component combination has been informally introduced. We must now face the problem of how to account for it in a linguistic analysis of Chinese characters. One way to account for it (and this is by no means the only way) is to construct a grammar to generate output objects which correspond to Chinese characters using components as the terminal symbols in the grammar. This is the approach followed in all the previous papers in this series except Burkart(1). Given that we wish to pursue the generative grammar approach the question then arises of what mechanism will enable us to characterize the spatial combination of components into characters. One way to represent it is by means of the process of frame-embedding. That process will now be introduced.

First,  is a frame, and represents all single-component characters, such as 木. Second, (1) , (2) , and (3)  are frames. (1) represents those two-component characters, like 相, in which the two components, (木 and 目 in this case) are horizontally arranged. (2) represents those two-component characters, like 亢, in which the two components (亠 and 几 in this case) are vertically arranged. (3) represents those two-component characters, like 困, in which the two components (口 and 木 in this case) are arranged in a surrounding/surrounded fashion. 困 is an instance of total surrounding; (3) also represents instances of partial surrounding, like 近, 庫, and 可. Frames for characters of component complexity greater than two are derived by means of the embedding of (1), (2), (3) in any subframe of (1), (2), (3) except the shaded subframe in (3): . The process of frame-embedding is recursive. That is, once a frame has been embedded in a subframe, any subframe of the derived frame (except ) may be embedded in, and so on without limit. Thus, for example, once  is derived from  any of its subframes can be embedded in, yielding, for example, , , or , etc.

Thus there are arbitrarily "large" frames in terms of the number of embeddings. This does not imply that there are arbitrarily large characters in terms of component-number. Our position is that there is an upper bound on the number of components per character[3], hence on frame size, but that (1) the precise location of the upper bound is not known and (2) the grammar would be less elegant if the upper bound were built in via, e.g., a loop counter.

There are presumably many kinds of restrictions we can impose on the above stated process. We could thus build a theory of frame-embedding which would be somewhat analogous to the theory of string languages, but that is not our purpose here. However, one restriction does have interesting results. Let us define each of the following pair of subframes as "partner" subframes:

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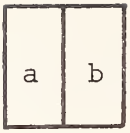
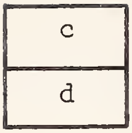
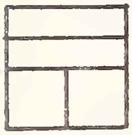
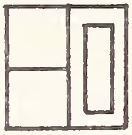
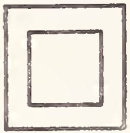
[3] In a sample of 400 characters from Mathews' (2), we found that the upper bound was 9.

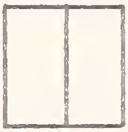
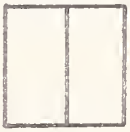
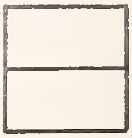


pair 1 (a,b)



pair 2 (c,d)

Now if at embedding time the partner of the "embedded in" subframe is blocked from future embedding, we can no longer derive such frames as  and , or generally any frame where there is embedding in both partner subframes of a pair. This restriction is worth mentioning because it is adhered to in the grammars in Rankin (3) and Rankin et. al.(4). Note that the border of  is always blocked, both in past work and in this presentation.

The blocking restriction has an important implication for the size of the lexicon. There are many characters which are complex in both partner subframes of a pair. Examples are: (1) 韶 , which is complex in both partner subframes of  ; (2) 髞 , which is complex in both partner subframes of  , and which further contains 高 , which is complex in both partner subframes of  . Such multiple complexity is quite common, and for a blocked grammar to generate such characters, it must list at least one of the complex structures in its lexicon. In the case of 韶 above, either 音 or 召 must appear in the lexicon, and obviously both are composed of components already in the lexicon: 音 = 亠, 䒑, 日 ; and 召 = 刀 , 口 . Consequently, lexicons in blocked grammars necessarily contain more entries than those in (partially) unblocked grammars.

So we see that there are two versions of frame embedding which have been used in grammars for Chinese characters: the blocked version (used previously) and the partially umblocked version (used in the current treatment). Given any version of frame-embedding there are many grammars based upon it which all derive their common syntactic power (i.e., their ability to impose certain kinds of constituent structure on generated characters) from the process of frame-embedding. They would differ from each other primarily in what components are listed in the lexicon and in how the components are classified. We now present one grammar based on the partially unblocked version of frame-embedding.

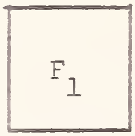
2. The Grammar

In this section we present a grammar capable of generating all the entries in Mathews' (2) minus two small classes of entries which are deliberately excluded. The first class of excluded entries are those traditional radicals which are not characters; that is, they are always bound, such as 氵 and 刂 . The second class consists of uncommon forms of characters which are more commonly represented by variant forms which are generated by the grammar. Here we refer to such uncommon forms as 爲 and 者, which are usually replaced by 為 and 者 in common practice.

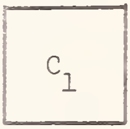
The grammar comes in two parts: a syntax and a lexicon. The two parts are linked by the use of component class marks. That is, the syntax generates all possible frames, with subframes filled by component class marks. The lexicon lists all components and marks them as members of certain of these classes. The lexicon further indicates certain component variation information. The outputs of lexical selection are frames filled with components -- our representation of Chinese characters. It is understood that components in distinct subframes do not touch each other.

2.1 The Syntax

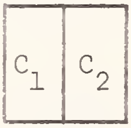
I. CHAR →



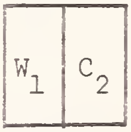
II. CHAR →



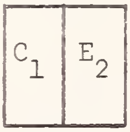
III. C →



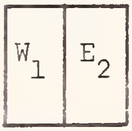
IV. C →



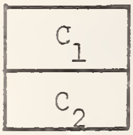
V. C →



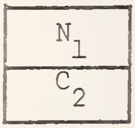
VI. C →



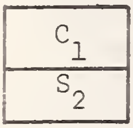
VII. C →



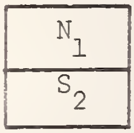
VIII. C →



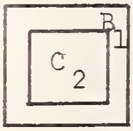
IX. C →



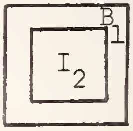
X. C →



XI. C →



XII. C →

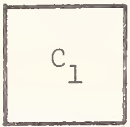
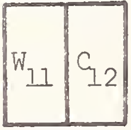
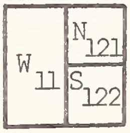


The syntax consists of twelve replacement rules (I, II, ..., XII) of the form p → q, where p is a non-terminal symbol (CHAR or C), and q is either a frame filled with one subscripted symbol or a frame filled with two subscripted symbols, terminal, non-terminal or mixed. The subscripts can be ignored for now. The terminal symbols are W=WEST, E=EAST, N=NORTH, S=SOUTH, B=BORDER, I=INTERIOR, and F=FREE. These terminal symbols are terminal with respect to the syntax. With respect to the total grammar, they are "sub-terminal" symbols, i.e., those symbols which are replaced by lexical items. The initial symbol of the syntax is CHAR (for CHARACTER), and every generation begins, by convention, with that symbol.

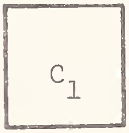
The generation of a terminal frame (i.e., a frame whose subframes are filled with terminal symbols) is as follows. A sequence of stages is created such that stage one is always the initial symbol CHAR, and stage two is either $\boxed{C_1}$ or $\boxed{F_1}$. In general, stage i + 1 is developed from stage i by the replacement of an occurence of C in stage i by any q of any rule in which p = C. When there are more than one occurrences of C in a stage, the question of which occurrence is replaced is determined by the subscript convention given below. The process continues until stage i contains no occurrences of C, or equivalently, until every subframe is filled with a terminal syntactic symbol.

Note that there is a subscript on each symbol occupying a subframe in the q portion of every rule. With each replacement of C, the subscripts on C are carried along to the symbols in q, and the subscript on the symbols in q is concatenated to the right of the subscript carried along from C. At any stage there may be several occurrences of C with subscripts. The C with the lowest valued subscript in lexicographic ordering is the next symbol to be replaced. For instance, 111 is lower valued than 12, etc. To determine the lowest-valued of two subscripts, the following test is made. At some position in a left to right scan of digit positions, there will be different digits, a 1 and a 2. The subscript containing the 1 at this position is the lowest valued. Example of generations of terminal frames are now given.

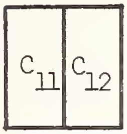
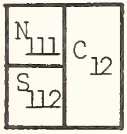
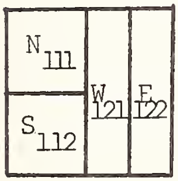
Example 1 (for the terminal frame which corresponds to 清)

	Stages	Authority
1.	CHAR	Initial Symbol Convention
2.		Rule II
3.		Rule IV
4.		Rule X

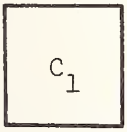
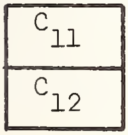
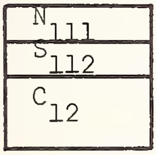
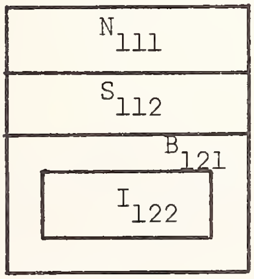
Example 2 (for the terminal frame which corresponds to 紝)

	Stages	Authority
1.	CHAR	Initial Symbol Convention
2.		Rule II

Example 2 (continued)

	Stages	Authority
3.		Rule III
4.		Rule X
5.		Rule VI

Example 3 (for the terminal frame which corresponds to 高)

	Stages	Authority
1.	CHAR	Initial Symbol Convention
		Rule II
		Rule VII
		Rule X
		Rule XIII

2.2 The Lexicon

The lexicon is a table with components heading the rows and component class marks heading the columns. An x at a row/column intersection point indicates that the component heading that row is a member of the class heading that column, and thus may replace that class mark in any terminal frame. Note that some occurrences of x are superscripted; these numbers indicate that a variation process is to be effected as the component heading the row replaces the class mark heading the column. The variation processes are stated on pages 28 to 31 immediately following the lexicon.

Lexical rules can be viewed as being of the same form as syntactic rules, namely $p \rightarrow q$, with the restriction that p is a component class mark and q is a component. The lexicon is thus an abbreviation of a very large number of such rules -- the number, in fact, of x's in the lexicon.

Given a terminal frame, the application of lexical rules is as follows. The subscripts on Σ , the component class marks, in the terminal frame are lexicographically ordered. The Σ with the lowest-valued subscript is considered first. The column headed by Σ is scanned and any component heading a row which has an x in Σ replaces Σ in the terminal frame. There is now a unique lowest valued subscript. The Σ associated with that subscript is now considered and an appropriate lexical replacement is effected. The process continues until every Σ is replaced by a component.[4]

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[4] Note that the use of subscripts results in an infinite number of nonterminal symbols. We are using these only as a notation device to reflect the history of the derivation. A detailed discussion of this would be appropriate in a paper concerned with theoretical issues.

The lexicon is now displayed. The components are numbered according to the format S.T.N. where S indicates the total number of strokes in the component, T the type of the last stroke in the component, and N the number of the component in the sub-list determined by S and T. The values of T are 1, 2, ..., 8 where 1 = horizontal, 2 = vertical, 3 = dot, 4 = \\-like, 5 = /-like, 6 = /-like, 7 = hooked, and 8 = multi-directional.[5]

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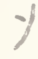
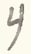
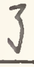
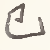
[5] 5 and 6 differ in direction. 5 is northeast to southwest, and 6 is southwest to northeast.

NUM	CHAR	W	E	N	S	B	I	F
1.1.1	一			X[5]	X		X	X
1.2.1	丨		X					
1.7.1	亅							X
1.7.2	乛			X				
1.8.1	乚		X				X	X
1.8.2	乙				X	X[5]	X	X
1.8.3	𠃊				X	X		
1.8.4	㇆		X			X		
1.8.5	𡿨	X	X					
2.1.1	⊢			X				
2.1.2	二		X	X	X	X[5]	X	X
2.1.3	ユ			X				
2.1.4	丄			X				
2.1.5	コ			X				
2.1.6	ニ			X				
2.1.7	ト			X				
2.2.1	丩	X	X				X	X
2.2.2	卩		X		X			X
2.2.3	十	X	X	X	X	X[5]		X

NUM	CHAR	W	E	N	S	B	I	F
2.2.4	凵					X		
2.2.5	亻	X						
2.2.6	丬	X	X					X
2.2.7	刂	X			X			
2.2.8	丅			X	X			
2.3.1	厶	X	X	X	X		X	X
2.3.2	卜		X		X		X	X
2.3.3	マ			X				
2.3.4	丷			X	X		X	
2.3.5	冫				X			
2.4.1	又	X	X	X	X		X	X
2.4.2	乂	X		X[5]	X[5]		X	X
2.4.3	人	X	X	X[5]	X		X	X
2.4.4	八		X	X	X			X
2.5.1	刀	X	X	X	X			X
2.5.2	力	X	X	X	X		X	X
2.5.3	入						X[5]	X
2.5.4	丿					X		
2.5.5	ソ			X				
2.5.6	厂					X		

NUM	CHAR	W	E	N	S	B	I	F	NUM	CHAR	W	E	N	S	B	I	F
2.5.7	九	X	X		X	X[1]	X	X	2.8.7	匚					X		
2.5.8		X					X		2.8.8	丂	X	X		X		X	X
2.5.9	厂					X			2.89				X				
2.5.10							X		2.8.10					X			X
2.5.11				X		X[5]			2.8.11		X	X	X	X		X	X
2.5.12		X							2.8.12	七			X	X		X	X
2.5.13				X		X[5]	X		2.8.13		X	X	X	X		X	X
2.6.1	刁		X		X			X	2.8.14	乃		X	X	X	X[5]		X
2.6.2		X			X				2.8.15		X						
2.7.1	丁	X	X		X	X[5]	X	X	2.8.16					X			
2.7.2				X	X				2.8.17	与					X		
2.7.3	刂		X														
2.7.4					X			X	3.1.1	士	X	X	X				X
2.7.5	了				X				3.1.2	土	X[2]	X	X	X		X	X
2.8.1		X	X	X	X		X	X	3.1.3	工	X[2]	X	X	X		X	X
2.8.2	几		X	X	X	X[1]	X	X	3.1.4	子	X[5]	X	X	X		X	X
2.8.3	勹			X		X		X	3.1.5		X						
2.8.4								X	3.1.6	口	X	X	X	X	X[5]	X	X
2.8.5	冂				X	X		X	3.1.7	上			X				X
2.8.6	儿				X		X	X	3.1.8				X	X			

NUM	CHAR	W	E	N	S	B	I	F	NUM	CHAR	W	E	N	S	B	I	F
3.1.9	三				X			X	3.3.1	弋		X	X		X[5]		X
3.1.10	乇						X	X	3.3.2	叉		X					X
3.1.11	女	X	X	X	X		X	X	3.3.3	幺	X	X	X	X			X
3.1.12	⺕			X[5]	X				3.3.4	刃	X	X	X			X	X
3.1.13	五			X					3.3.5	丸		X	X			X	X
3.1.14	𠂉			X					3.3.6	凢		X	X				X
3.1.15	⺊				X				3.3.7	寸		X		X		X	X
3.2.1	巾	X	X		X		X	X	3.3.8	凡		X	X	X			X
3.2.2	千	X[5]	X	X	X	X[5]		X	3.3.9	云			X	X			
3.2.3	干	X	X	X	X[5]	X[5]	X	X	3.3.10	勺		X		X			X
3.2.4	阝	X	X					X	3.3.11	夕	X	X	X	X		X	X
3.2.5	山	X	X	X	X		X	X	3.3.12	厶	X						
3.2.6	扌				X		X[5]	X	3.3.13	下		X	X	X			X
3.2.7	卄			X	X[5]		X	X	3.3.14	乍	X	X	X				X
3.2.8	丫	X						X	3.3.15	小		X	X	X		X	X
3.2.9	亻	X							3.3.16	犬					X		
3.2.10	彳	X							3.3.17	么	X	X		X		X	X
3.2.11	才					X			3.3.18	忄	X						
3.2.12	卜		X						3.3.19	文				X			
3.2.13	午	X							3.3.20	⺍	X						

NUM	CHAR	W	E	N	S	B	I	F
3.3.21	儿				X			
3.3.22	巛				X			
3.3.23	冈				X			
3.4.1	大	X	X	X[5]	X		X	X
3.4.2	丈		X					X
3.4.3	欠		X		X		X	X
3.4.4	廴					X		
3.4.5	丞							X
3.4.6	以				X			
3.4.7	夂			X	X	X[4]		X
3.4.8	氏		X					
3.5.1	才		X				X	X
3.5.2	尸	X				X		X
3.5.3	彡	X	X	X	X		X	X
3.5.4	乡	X						
3.5.5	勿		X					X
3.5.6	广					X		
3.5.7	屮	X	X	X[5]	X		X	X
3.5.8	歹	X						
3.5.9	万				X			
3.5.10	少				X			
3.5.11	⺌			X				
3.5.12	为						X	
3.6.1	扌	X						
3.6.2	氵	X						
3.6.3	子	X						X
3.7.1	于		X	X	X		X	X
3.7.2	宀			X				
3.7.3	宁		X					
3.8.1	兀		X		X	X[1]		X
3.8.2	尢			X		X[1]		X
3.8.3	已		X					X
3.8.4	巳	X	X	X			X	X
3.8.5	己	X	X	X				X
3.8.6	乇	X	X	X	X		X	X
3.8.7	弓	X	X		X	X[5]		X
3.8.8	门					X		
3.8.9	凡		X					X
3.8.10	亏		X		X			X
3.8.11	也		X		X		X	X

NUM	CHAR	W	E	N	S	B	I	F
3.8.12	丂					X		
4.1.1	曰							X
4.1.2	[illegible]			X	X			X
4.1.3	冃	X						X
4.1.4	丑		X				X	X
4.1.5	月	X	X	X	X^{5}		X	X
4.1.6	止	X^{2}	X	X	X		X	X
4.1.7	[illegible]			X				
4.1.8	王	X^{2}	X	X	X		X	X
4.1.9	丗			X				
4.1.10	五		X	X				X
4.1.11	生			X				X
4.1.12	壬		X		X		X	X
4.1.13	廿			X				X
4.1.14	互		X					X
4.1.15	丹	X	X				X	X
4.1.16	毋			X			X	X
4.1.17	白				X	X		
4.1.18	日^{5}	X	X	X	X		X	X
4.1.19	主	X	X	X	X			X
4.1.20	毋							X
4.1.21	四			X				
4.2.1	牛	X	X	X	X		X	X
4.2.2	开	X	X		X		X	X
4.2.3	冊				X			
4.2.4	井		X		X			X
4.2.5	中		X	X			X	X
4.2.6	斤	X	X		X		X	X
4.2.7	弔	X	X					X
4.2.8	午		X^{5}		X			X
4.2.9	申			X				X
4.2.10	升			X	X			X
4.2.11	州							X
4.2.12	币		X		X		X	X
4.2.13	丯	X	X	X^{5}	X^{5}			X
4.2.14	斗		X		X		X	X
4.2.15	冃				X	X^{5}	X^{5}	
4.2.16	手				X			
4.2.17	丰	X	X					

NUM	CHAR	W	E	N	S	B	I	F	NUM	CHAR	W	E	N	S	B	I	F
4.3.1	心	X	X	X	X		X	X	4.4.4	夭		X	X	X			X
4.3.2	内		X		X	X		X	4.4.5	天		X	X	X		X	X
4.3.3	太		X	X	X			X	4.4.6	𧘇				X			
4.3.4	不		X	X	X		X	X	4.4.7	水		X	X	X		X	X
4.3.5	歹	X			X		X	X	4.4.8	𧘇				X[5]		X	X
4.3.6	戈	X	X	X	X	X[5]	X	X	4.4.9	之				X			X
4.3.7	犬	X	X	X	X		X	X	4.4.10	辶					X		
4.3.8	叉			X				X	4.4.11	不							X
4.3.9	于				X			X	4.4.12	尺				X	X[4]	X	X
4.3.10	尤		X	X	X	X[1]	X	X	4.4.13	木	X[3]	X	X	X[5]		X	X
4.3.11	夕	X		X				X	4.4.14	爪		X		X	X[4]		X
4.3.12	小				X			X	4.4.15	夊		X					X
4.3.13	灬				X		X		4.4.16	火	X	X	X	X		X	X
4.3.14	小				X				4.4.17	止				X			
4.3.15	幺			X					4.5.1	尹		X		X	X		X
4.3.16	不				X				4.5.2	户	X	X			X		X
4.3.17	弋					X			4.5.3	东		X					X
4.4.1	夫	X	X		X		X	X	4.5.4	片	X						X
4.4.2	夬	X	X	X				X	4.5.5	幺			X				
4.4.3	及		X		X			X	4.5.6	牙	X	X		X		X	X

NUM	CHAR	W	E	N	S	B	I	F
4.5.7	尸				X	X		X
4.5.8	歹					X[5]	X	X
4.5.9	夬					X		
4.5.10	少	X	X	X		X[5]		X
4.5.11	丰	X						
4.5.12	手				X			
4.5.13	手	X				X		
4.6.1	牛	X						
4.7.1	氏		X		X			
4.7.2	手		X		X			
4.7.3	聿				X			
4.8.1	元	X	X	X	X	X[1]	X	X
4.8.2	旡	X	X	X				X
4.8.3	巴		X		X		X	X
4.8.4	屯	X	X		X		X	X
4.8.5	冘	X	X	X				X
4.8.6	毛	X	X	X	X	X[1]	X	X
4.8.7	公					X		
4.8.8	无							X
4.8.9	巳						X	X

NUM	CHAR	W	E	N	S	B	I	F
4.8.10	门				X			
4.8.11	方	X	X		X		X	X
4.8.12	丐		X					X
4.8.13	丐		X					X
4.8.14	片	X						X
5.1.1	虫			X				X
5.1.2	丘	X	X	X				X
5.1.3	圭			X	X			X
5.1.4	目	X	X	X	X		X	X
5.1.5	且	X	X		X		X	X
5.1.6	巨		X		X			X
5.1.7	吕		X		X			X
5.1.8	互		X					X
5.1.9	册	X	X					X
5.1.10	廿	X	X	X	X		X	X
5.1.11	正	X[2]	X	X	X		X	X
5.1.12	企						X	X
5.1.13	聿			X				X
5.1.14	业			X	X		X	X

NUM	CHAR	W	E	N	S	B	I	F
5.1.15	生	X[2]	X	X	X		X	X
5.1.16	非			X	X			
5.1.17	凹			X				X
5.1.18	凸							X
5.1.19	本		X		X			X
5.1.20	疋	X[2]						X
5.1.21	冉		X		X			X
5.1.22	四		X	X	X			X
5.1.23	皿				X			X
5.1.24	白	X	X	X	X		X	X
5.1.25	由		X	X	X		X	X
5.1.26	母		X	X	X			X
5.1.27	田	X	X	X	X		X	X
5.1.28	巨			X				
5.1.29	[illegible]	X						
5.2.1	申		X					X
5.2.2	弗		X	X	X		X	X
5.2.3	半	X	X					X
5.2.4	甲	X	X	X[5]			X	X
5.2.5	出		X	X	X		X	X

NUM	CHAR	W	E	N	S	B	I	F
5.2.6	聿			X				
5.2.7	平		X		X		X	X
5.2.8	[illegible]				X			
5.2.9	手		X					
5.2.10	申			X				
5.2.11	卯		X		X	X[5]		X
5.3.1	朮		X				X	X
5.3.2	民	X						X
5.3.3	氏	X	X				X	X
5.3.4	水				X			X
5.3.5	玉				X			X
5.3.6	戊				X	X[5]		X
5.3.7	瓦		X		X			X
5.3.8	斥		X					X
5.3.9	丙	X	X	X	X		X	X
5.3.10	礻	X						
5.3.11	必		X	X	X		X	X
5.3.12	去				X			
5.3.13	内				X			
5.3.14	太			X				

NUM	CHAR	W	E	N	S	B	I	F
5.4.1	皮	X	X		X		X	X
5.4.2	未	X	X				X	X
5.4.3	末		X		X			X
5.4.4	氶			X				X
5.4.5	瓜	X	X		X	X[4]	X	X
5.4.6	央		X	X	X			X
5.4.7	永		X	X		X[4]		X
5.4.8	失		X		X		X	X
5.4.9	水				X			
5.4.10	反			X			X	X
5.4.11	吏			X			X	X
5.4.12	禾				X			X
5.4.13	疋				X			X
5.4.14	奴			X			X	X
5.4.15	夫			X				X
5.4.16	乏		X		X			X
5.4.17	史		X					X
5.4.18	乐	X[3]	X	X	X		X	X
5.4.19	飞			X				
5.5.1	弗				X			X
5.5.2	户					X		
5.6.1	乒	X						X
5.6.2	疒					X		
5.7.1	民	X	X	X				X
5.7.2	乎		X				X	X
5.8.1	电				X			X
5.8.2	包	X	X		X		X	X
5.8.3	电				X			X
5.8.4	寿	X	X					X
5.8.5	世		X	X			X	X
5.8.6	甩							X
5.8.7	为					X		
5.8.8	馬					X		
5.8.9	北	X		X		X[5]		X
6.1.1	自		X	X	X			X
6.1.2	臼		X	X	X		X	X
6.1.3	血	X[2]	X	X				X
6.1.4	聿			X				X
6.1.5	自	X	X	X	X		X	X

NUM	CHAR	W	E	N	S	B	I	F	NUM	CHAR	W	E	N	S	B	I	F
6.1.6	亚			X	X			X	6.3.2	戊		X				X	X
6.1.7	西		X	X	X		X	X	6.3.3	戉				X			X
6.1.8	再							X	6.3.4	成		X	X	X			X
6.1.9	襾		X					X	6.3.5	𢦏					X		
6.1.10	覀		X	X	X			X	6.3.6	兆	X	X	X	X		X	X
6.1.11	舟	X	X					X	6.3.7	乒							X
6.1.12	壬				X^2				6.3.8	兵							X
6.1.13	曲			X					6.3.9	虫	X^5	X	X	X		X	X
6.1.14	面			X					6.3.10	录						X	X
6.1.15	且			X					6.3.11	㠯	X			X			X
6.1.16	四				X				6.3.12	戋					X		
6.1.17	丗			X					6.3.13	※						X	
6.1.18	其			X					6.3.14	栽				X			
6.2.1	甲				X			X	6.4.1	吏		X					X
6.2.2	缶	X			X		X	X	6.4.2	東	X	X	X	X			X
6.2.3	角	X						X	6.4.3	艮		X	X			X	X
6.2.4	聿		X		X		X	X	6.4.4	朱	X	X	X	X			X
6.2.5	半				X			X	6.4.5	耒	X	X					X
6.2.6	耳	X^5	X		X	X^5	X	X	6.4.6	叀	X	X				X	X
6.3.1	衣	X							6.47	米	X	X	X	X		X	X

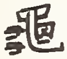
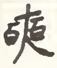
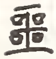
NUM	CHAR	W	E	N	S	B	I	F
6.4.8	美			X				X
6.4.9	永				X			
6.4.10	火			X				X
6.4.11	夗			X				
6.5.1	曳		X					X
6.5.2	男	X	X		X		X	X
6.5.3	甶			X				
6.7.1	且			X				
6.7.2	凹			X		X[5]		
6.8.1	身	X						X
6.8.2	臣	X	X		X		X	X
6.8.3	卌			X				
6.8.4	鸟					X		
6.8.5	冎					X		
7.1.1	酉	X	X		X			X
7.1.2	里	X[2]	X	X	X		X	X
7.1.3	缶	X						X
7.1.4	坐	X	X		X		X	X
7.1.5	巫	X	X		X			X

NUM	CHAR	W	E	N	S	B	I	F
7.1.6	齒			X				X
7.1.7	臼					X		
7.1.8	重				X			
7.1.9	西			X				
7.1.10	巫			X				
7.1.11	皀		X					
7.2.1	串			X				X
7.2.2	車	X	X	X	X		X	X
7.2.3	甲			X				
7.3.1	南	X	X		X			X
7.3.2	甫		X	X	X		X	X
7.3.3	求	X	X				X	X
7.3.4	我	X	X		X			X
7.3.5	鱼				X[5]		X	X
7.3.6	率			X				X
7.3.7	兩				X			X
7.3.8	隶				X		X	X
7.3.9	卵							X
7.4.1	夾	X	X	X	X		X	X
7.4.2	釆	X	X	X	X		X	X

NUM	CHAR	W	E	N	S	B	I	F	NUM	CHAR	W	E	N	S	B	I	F
7.4.3	足		X		X	X[4]		X	8.1.6	非		X	X	X		X	X
7.4.4	良	X	X		X		X	X	8.2.1	肅						X	X
7.4.5	更		X			X[4]		X	8.2.2	串			X				X
7.4.6	東	X[3]	X		X		X	X	8.2.3	垂				X			
7.4.7	走		X			X[4]		X	8.3.1	兩		X				X	X
7.4.8	豕	X	X		X	X[4]	X	X	8.3.2	隶		X				X	X
7.4.9	臭				X				8.3.3	重	X		X				X
7.5.1	豸	X							8.3.4	雨			X			X	X
7.5.2	身	X	X					X	8.3.5	戠					X		
7.7.1	臥				X				8.3.6	我					X		
7.8.1	見		X		X	X[1]		X	8.3.7	戕					X		
7.8.2	鳥					X			8.3.8	𢦔					X		
7.8.3	皃					X[1]	X	X	8.4.1	果	X	X	X	X			X
7.8.4	臣	X	X					X	8.4.2	承							X
									8.4.3	疌		X					X
8.1.1	亟		X					X	8.4.4	東		X					X
8.1.2	亞	X	X	X	X		X	X	8.4.5	兒	X	X				X	X
8.1.3	罡			X					8.4.6	來	X	X		X			X
8.1.4	𦥑			X		X			8.4.7	兼		X					X
8.1.5	亜	X						X	8.7.1	事	X						X

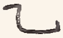
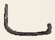
NUM	CHAR	W	E	N	S	B	I	F
8.7.2	亟			X				
8.8.1	乖							X
8.8.2	虎					X		
8.8.3	門		X			X		X
9.1.1	垂		X		X		X	X
9.1.2	重	X	X		X		X	X
9.1.3	缶	X	X					X
9.1.4	亞	X	X		X			X.
9.1.5	巠	X						X
9.2.1	崩		X					X
9.2.2	叀	X	X					X
9.3.1	飛				X			X
9.3.2	風				X	X[1]	X	X
9.3.3	禺		X	X	X		X	X
9.3.4	禹	X					X	X
9.4.1	東		X				X	X
9.4.2	是					X[4]		X
9.7.2	臼					X		

NUM	CHAR	W	E	N	S	B	I	F
10.1.1	隺	X	X					X
10.1.2	重			X				X
10.2.1	卒				X			X
10.3.1	鬼		X		X	X[1]		X
10.4.1	乘	X	X					X
10.4.2	兼	X	X				X	X
10.7.1	門					X		X
11.1.1	雀							X
11.1.2	善				X			X
11.2.1	畢		X		X			X
11.3.1	麥	X				X[5]		X
11.4.1	爽	X						X
12.3.7	兩				X			X
12.8.1	堯		X		X	X[1]	X	X
13.1.1	黽		X		X			X
13.2.1	肅	X	X		X			X
13.7.1	鼠	X			X	X[5]		X

NUM	CHAR	W	E	N	S	B	I	F	NUM	CHAR	W	E	N	S	B	I	F
13.8.1	鼎				X			X									
14.4.1	爾	X	X	X			X	X									
14.4.2					X		X	X									
15.4.1			X					X									
16.1.1			X					X									

2.3 Variation

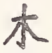
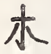
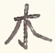
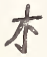
VARIATION PROCESS 1, (BORDER)

For certain components whose base forms have or in their "eastern" portions, this process causes the BORDER variant to assume a shape wherein becomes  and becomes  .

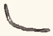
VARIATION PROCESS 2, (WEST)

For certain components which have in their "south central" portions, this process causes the WEST variant to assume a shape wherein becomes .

VARIATION PROCESS 3, (WEST)

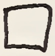
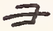
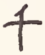
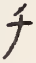
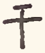
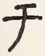
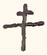
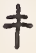
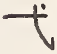
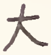
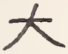
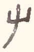
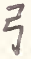
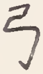
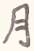
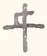
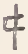
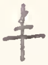
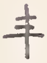
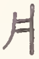
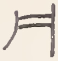
For certain components which contain  or a  -like structure, this process causes the WEST variant to assume a shape wherein  becomes  .

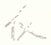
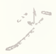
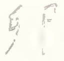
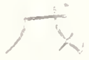
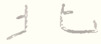
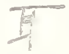
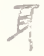
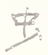
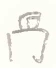
VARIATION PROCESS 4, (BORDER)

For certain components which have or in their "south-eastern" portions, this process cuases the BORDER variant to assume a shape wherein or become  .

Ad hoc Variations

Number	Base Form	Position	Variant
1.1.1	一	N (sometimes)	一
1.8.2	乙	B	乙
2.1.2	二	B	二
2.2.3	十	B	𠂇
2.4.2	乂	N	㐅
		I (sometimes)	㐅
		S (sometimes)	㐅
2.4.3	人	N	𠆢
2.4.4	八	N,S	ハ
2.5.3	入	I (sometimes)	入
2.5.11	丆	B	丆
2.5.13	𠂇	B	𠂇
2.7.1	丁	B	丁
2.8.14	乃	B	乃
3.1.4	子	W	子

Number	Base Form	Position	Variant F
3.1.6		B	
3.1.12		sometimes	
3.2.2		B,W (sometimes)	
3.2.3		B,S (sometimes)	
3.2.6		I (sometimes)	
3.2.7		S	
3.3.1		B	
3.4.1		N (sometimes)	
3.5.7		N (sometimes)	
3.8.7		B	
4.1.5		S	
4.1.18		sometimes	
4.2.8		E	
4.2.13		N,S	
4.2.15		B	
		I	

Number	Base Form	Position	Variant
4.3.6	戈	B	
4.4.9	氏	S	
4.4.14	朮	S (sometimes)	
4.5.8	豕	B	
4.5.10	少	B	
5.2.11	卵	B	
5.3.6	戊	B	
5.8.9	北	B	
6.2.6	耳	B	
		W	
6.3.10	虫	W	
6.7.2	四	B	
7.3.5	缶	S (sometimes)	

3. Concluding Remarks

This grammar is an attempt to characterize component combination from a particular point of view. The three modes of component combination which are utilized are precisely the productive ones. It is an experimental grammar and not a candidate for final success. The following remarks are intended to evaluate the grammar as such an attempt.

First, the grammar generates all the characters in Mathews' (2)[6] and every other unabbreviated Chinese character that we know of. Consequently, it constitutes a very compact defining device for a large complicated language. However, the grammar overgenerates its target language in the sense that some permitted sequences of rules result in the generation of structures which are clearly not acceptable Chinese characters. In future attempts, further constraints could be imposed along the lines discussed on page 5,ff in Rankin et. al. (4) to reduce this unacceptable output.

Second, the grammar preserves the distinction between component combination and stroke combination mentioned earlier. It does this by allowing only three modes of combination each of which operates on spatially disjoint arguments. It disallows such operations as touching and crossing of arguments which are characteristic of stroke combination.

There is an accompanying disadvantage to disallowing touching and crossing because some instances of component combination cannot be explained by the grammar. For example, by disallowing crossing, we preserve the integrity of 十 , which is good, but also have to treat 東

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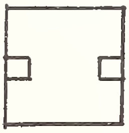
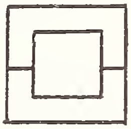
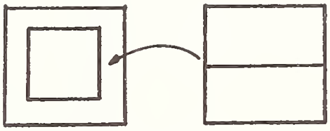
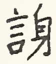
[6] Barring clerical errors in the lexicon.

as a component, which is unfortunate, since 朩[7] and 日 are components themselves. There are quite a few "components" like 東 , which can be further segmented into smaller components.

Third, our process of frame-embedding produces a very simple, regular class of frames. There is a disadvantage that comes with this simplicity, however, and that is a certain lack of coverage. A fairly large number of multi-component structures is left unexplained due to the simplicity feature. Examples are 來 (木, 人, 人) which might require some such frame as  , and 是 (日 , 疋) as a border. Segmenting 是 would require embedding in the border subframe perhaps yielding  from  .

Fourth, the grammar generates some output characters in more than one way. For example, 謝 is generated as 言 plus 射 and also as  plus 寸 . We feel that most of these ambiguities correctly reflect the state-of-the-art of the linguistic analysis of Chinese characters in that we are not in all cases ready to select one analysis of a character as being correct and have the grammar suppress all other analyses. See Rankin et.al. (4) pages 56 ff for a detailed discussion of ambiguity problems.

Future grammars might examine the internal structure of components in the present lexicon in order to segment them if they contain substructures which are themselves already in the lexicon. This would require recognition of types of component combination which are far less common than those discussed in this paper. In particular, this would involve recognizing various types of superimposition and other component combination possibilities such as those underlying 來 and 是 discussed above. It is thought that one result of this work might be the development of complex frames which would correspond to instances of superimposition and other rare combination possibilities.

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[7] 朩 is a variant form of 木 , component number 4.4.13.

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